Mendocino County. The interior towns suffered very little. the severest shocks were at Albion, Comptche, and Christine.

April 25.—Severe at Albion and Mendocino, Prairie Camp, Greenwood, Noyo, and Fort Bragg.

LIGHTNING ON THE KITE WIRE.

Ever since the historical experiments of Franklin in Philadelphia, and of DeRomas in France, it has been a question to what extent it might be dangerous for the meteorologist to handle the wet cord or the modern iron or steel wire used in flying kites during thunderstorms. The early observers in Europe recommended a distinct safety connection or grounding of the wire a short distance in front of the observer. Rather severe shocks have been received in the ordinary course of kite flying, but so far as the record shows nothing really dangerous to human life. It was from the beginning evident that a dry cord could not convey a dangerous charge of electricity from the sky to the earth. We now know that the resistance of such a cord is so great that it would be burned or destroyed by small discharges long before a lightning flash occurs. It is only in proportion as the line becomes a more perfect conductor that it can have any appreciable influence in determining the location of the path of the discharge. When Professor Richman was struck dead in his laboratory by a discharge of lightning, at St. Petersburg, he was using outside of the building a much larger conductor than would ever be associated with a kite. The strongest shocks hitherto observed, as received from kite lines, were those observed by DeRomas when he used a strong linen cord around which a small copper wire was wound, but these did him no harm.

These ancient experiments are brought to mind by the recent experience of some of the aerial observers for the Weather Bureau, whose reports have been kindly placed at the Editor's disposal by Professor Marvin.

Mr. E. E. Spencer, aerial observer, reports that at his station (Fort Thomas, near Cincinnati, Ohio), at 6 a. m., May 16, the kite line wire was completely destroyed by a heavy electric discharge from the air. The kite and meteorological register were landed safely about 20 miles distant and secured in good condition. About 12,000 feet of wire were out and 500 still remained on the reel, but all was burned or spoiled. Mr. Spencer says:

The kite was started shortly after 4 a. m., seventy-fifth meridian time, and after the first few hundred feet of line had been payed out it struck a good current of air, and had taken out 5,000 feet of wire at 5 a. m. and 10,000 feet at 6 a. m. Observations were taken at both these hours. The kite was flying so steadily and at a very nice angle that I let out 12,160 feet, and was going to take an observation at 6:15 a. m. I had but just left the reel for this purpose when a very heavy electric current literally burned the wire up, particles of the melted wire adhering to the reel. A stream of fire seemed to run from the kite to the reel, completely burning the entire line. To me the most singular feature about it is the fact that at the time the wire was burned the kite was flying in a comparatively clear sky to the northeast, although a bank of clouds was visible in the west and a very light shower fell a few minutes afterwards, continuing but a couple of minutes. No thunder was heard here. We watched the kite drift rapidly away to the northeast until it was lost to view away across the river, and then we went for it. The kite was tagged, with directions for notifying me if found. I notified all postmasters and school-teachers within 20 miles and put similar notices in the newspapers. While I congratulate myself that I did not have hold of the reel when the wire parted, yet I may say that I had examined the switch less than two minutes before, and there was apparently very little electricity going through the wire, and we were congratulating ourselves that we were going to have a successful ascension after five days of hard work.

At Lansing, Mich., Mr. Charles A. Hyle, aerial observer, reports that—

On May 18 the Weather Bureau kite was launched at 7:47 a. m.; by 8:01 7,500 feet of wire had been reeled out; at 8:20 a. m. distant thunder was heard in the west, and the wire began to be reeled in; rain began to fall at 8:52; at 9 a. m. a powerful bolt of lightning came down the wire, which was quickly consumed. From my position at the reel, where I had command of both brakes, I saw a shower of sparks, accompanied by a sharp report, and then a rope of smoke, stretching from the reel to the kite. In holding the wooden levers, I had released the iron guiding-bar, which action I believe saved me from a heavy shock; the slight one that I did receive stunned me for an instant. Many citizens who were watching the kite report that a column of fire about a foot in diameter seemed to come down the wire; but those who were at a distance claim that the fire seemed to rise to the kite. All are agreed that the wire seemed to be on fire from one end to the other; immediately afterwards a rope of smoke appeared throughout the length of the wire. As many as thirteen places were found where the discharge had jumped from the wire to the brake strap and penetrated the reel, one of them forming a weld between the brake strap and the reel. The kite was found about 4 miles north of the reel, only two sticks were broken and will be repaired in a short time. The safety wire was fused, as also several of the guy wires. When the damaged wire that remained on the reel was removed, it was found that 4,420 feet were serviceable, and 4,015 feet had been destroyed by the discharge.

Under date of May 28, Mr. Paul DeGraw, aerial observer at Springfield, Ills., says:

On the 27th, at 4 p. m., when 6,000 feet of kite line were out, a storm was seen approaching from the southwest. The work of reeling in the kite was begun immediately, and at 4:30 p. m., when the rain began, the dial reading was 503. A very few moments later the kite was apparently struck by lightning, which destroyed the wire between the kite and a point about 3 feet from the reel, without harming the reel or the wire wound upon it. The kite was found about 1¼ mile north of the station, slightly damaged by the lightning. The amount of wire lost was 2,297 feet.

In a report from Mr. G. Harold Noyes, aerial observer at Topeka, Kans., dated May 31, he says:

A kite ascension was made at 9:12 this morning and at 10:47 an altitude of 5,047 feet was observed. In pursuance of circular of May 26, from Chief of Instrument Division in regard to electrical discharge in the thunderstorm season, I watched the amount and intensity of the electricity coming down the line, and at 11:50 I noticed it to be increasing. My assistant and I commenced to reel in the 8,000 feet of line that were then out, but it rained soon after we commenced reeling. We had just reeled in a little more than 3,000 feet, when without warning a bolt of electricity came down the wire, burning and breaking it, setting loose the kite. The concussion was so great that people standing 1,000 feet away thought we were shooting. We were reeling the kite in the usual manner, each with a hand on the iron steering handle of the reel-box; the discharge stunned us measurably. * * * It was some moments before we could realize all that had happened. * * * The kite which had an elevation of some 3,000 feet had fallen nearly out of sight before we recovered our self-possession. The wire was hot when I picked it up and was burned brittle and black. The kite fell to the ground breaking only one stick; it is burned a little at one corner which is evidently the point where the discharge entered. The self-registering apparatus is uninjured. The breaking of the wire was not caused by a continuous flow of electricity, but apparently by a single discharge. The rest of the wire on the reel is, I think, still good.

We do not know that any provision can be made for the prevention of the burning of the kite line when once a powerful discharge from the sky falls upon it. The line is too delicate to stand such discharges as must occur in the neighborhood of thunderstorms. It would destroy the efficiency of the kite to make the wire much larger and, for the present, of course, it will be best not to expose the kite line to the chances of destruction.

Undoubtedly the discharges that destroy the wire are but preliminary ones, indicating the proximity of a still more *disturbed condition, with severe lightning and thunder.* If electrical apparatus and expert observers were sufficiently numerous we should long since have been able to determine the breadth of the zone about any storm-center within which it is useless to attempt to fly kites with fine steel wire. No such destructive discharges are recorded in ordinary fair weather, but there is always some electricity on the wire and, of course, a connection between the reel and the ground is always at hand to carry off the small discharges that annoy the operator.

It will be observed that in the four preceding cases thunderstorms were reported from stations within 100 or 200 miles of the kite at the regular 8 a. m. telegraphic report. The kites were being flown in regions within which rain had fallen during the preceding twelve hours, where cloudy weather still prevailed, and where the surface winds were southerly, midway between regions of high and low pressure.

Afternoon thunderstorms are often called heat thunderstorms, because their occurrence is evidently dependent directly upon local temperatures. The thunderstorms that injured our kites on the mornings of May 16, 18, 27, and 31 all occurred as a part of wide-spread systems of thunderstorms attending general areas of low pressure. These have all been classed as "cyclonic" thunderstorms. These areas pass over the country at about the same rate as the areas of low pressure, but the thunderstorm region reaches out to a point about midway between the areas of low pressure and high pressure. By studying the weather map of the previous evening one may almost certainly foresee whether it will be safe to make the kite ascension early the next morning. It is evident that the successful use of the kite in the central portion of the Mississippi watershed, which is now covered by our sixteen kite stations, will depend upon the distribution of the tracks of the areas of low pressure.

The study of atmospheric electricity was prosecuted in former years until, under the advice of Prof. T. C. Mendenhall, it was decided that the electrometer and water-dropping collector was not likely to be of any practical value in weather forecasting. The study was, therefore, laid aside until some other reason should appear for the further prosecution of the subject. It is generally believed that the electrification of the air is not a matter of great importance in the study of the mechanics of the atmosphere. The electrification seems to be one of the minor results of the formation of fog, haze, cloud, and rain. Thus, Elster and Geitel, in their review of recent investigations into the subject of atmospheric electricity (see Weather Bureau Bulletin 11, Part 2, p. 514), say:

> Since regions of precipitation show the greatest variation of potential the question arises whether such regions may be detected at a great distance by the behavior of the electrical apparatus; that is, whether it will not be possible to employ electrical measurements for forecasting the weather. This idea was tested in an extensive series of observations by Mendenhall. A negative result was obtained. One must, therefore, consider the electrical developments attending upon precipitation as being essentially local and these may be excluded in the investigation of normal electricity. * * * One can either consider the whole earth as a sphere with a negative charge of electricity acting upon the atmosphere and the regions above it by induction, which is Exner's method of treatment, or he may, like Lord Kelvin, consider the atmosphere as the dielectric of a condenser of which the lower side, or the earth surface, is negative, and the upper side, or upper layer of the atmosphere, is positive.

The electric condition at the surface of the earth is subject to an annual and a diurnal variation, but still more to a nonperiodic variation known as the electric storm. Exner shows the great need of measurement of potential fall at great heights above the earth's surface. Possibly the kite will offer an interesting method of attaining this desideratum. Efforts in this direction have been made by Mr. A. G. McAdie. If the electricity originates in the earth, then it must be considered as being dissipated by discharge into the atmosphere, and the daily and annual variations of the normal terrestrial charge should be accompanied by an opposite daily and annual variation in the normal atmospheric charge. The electrical phenomena attending rain or other form of precipitation must be considered as disturbances of the normal electrical field.

The origin of the electrification observed on the kite wire, and the manner of transfer of electricity from the air to the wire, and *vice versa*, are but little understood. Professor Marvin calls attention to the differences observed on different occasions, as follows: Sometimes everything goes to show that the wire is being continuously electrified, little by little, just as if every particle of air impinging upon the wire communicated to it, or carried away, a minute electrical charge. This seems to be the only circumstance of electrification in the winter time. In the summer season, however, in addition to the above phenomenon, he finds that sudden, often very considerable, impulsive rushes of electricity pass over the wire without the slightest apparent cause and in an infrequent and most irregular manner. All such discharges are strictly momentary, and, when one has been observed to pass, others are sure to follow, although several seconds, or even minutes, may intervene.

Professor Marvin says his kite wire, in these cases, is the receiving instrument in an immense, wireless, telegraphic system. Nature is producing signals along his kite wire, which mean that flashes of lightning are passing at some far distant point; only rarely are these perceptible to the ordinary senses. All currents of the above described character may be called inductive discharges. It seems probable in some cases that such currents may be strong enough to fuse the wire. This appears to have been the case at Cincinnati. Finally, the wire may be charged with electricity by being actually struck with lightning; that is, the wire forms part of the path chosen by the bolt in passing between the clouds and the earth. There thus appear to be at least three different conditions leading to the electrification of the kite line.

So long as the wire is grounded the variations of potential at the earth and the upper end of the wire will always be sufficient to produce some slight currents; the wind blowing past the kite and wire tends to reduce the latter to the same electric potential as that of the air.

The Editor has often experienced the tingling sensations and the violent nervous shock produced when a natural bolt of lightning has struck within a hundred feet of him and he regards the discharges precipitated on to these Weather Bureau kite wires as miniature premature bolts, probably too feeble to do any serious damage. The discharges that are brought down the kite line are to be considered as timely warnings. They may destroy the kite wire, but they tend to save the observer. They act like the patent fuses that melt before the boiler explodes or the electric fuses that protect the dynamos, and are as precious to the observer in a thunderstorm as the safety wire in the bridle of the kite is important to it in a windstorm.

The kite wire used by the Weather Bureau is of the highest grade of steel, 0.028 inch in diameter, having a tensile strength of about 210 pounds, or at the rate of about 350,000 pounds to the square inch.

Professor Marvin has employed the electric light current from the small dynamo of the Weather Bureau in testing the carrying power of the steel kite wire, and finds that a continuous current of about 15 amperes at about 100 volts is required to heat the wire to full red incandescence and maintain it at that temperature. Nearly a minute of time was consumed in reaching the maximum heat. This is doubtless the minimum strength of a destructive current, inasmuch as the wire must be torn assunder by the pull of the kite by the time it reaches a full red heat under a more or less steady current. Just how much greater current would be carried by the line when instantly fused by a momentary current in the full ventilation of the wind is difficult to estimate, but it is undoubtedly much higher than the current employed in the test.

At a red heat the resistance of the wire is shown, by the rough tests made, to be about 0.7 ohm per foot, but this is nearly five times greater than the resistance when cold. From these data we are led to deduce that the electrical discharge which fused the 12,000 feet of line near Cincinnati had a potential of at least 130,000 volts.

Of course we are very sorry to lose a continuous meteorological record within a thunder cloud, just because the lightning persists in burning up our kite line; but the record must be obtained; the progress of meteorology must not be thwarted; a simple method for overcoming the difficulty must be found.

CORRIGENDA.

February REVIEW, 1898, page 61, table for Honolulu, for "1897" read "1898"; maximum and minimum temperatures for February 8, read "79" and "63"; all those given for February 8–27 to be dropped one line, and belong to February 9–28.

REVIEW for March, 1898, page 103, Mexican table, for "Tuxtla (Gutierrez)" read "Tuxtla, Gutierrez (Chiapas)." Page 107, line 24 from bottom, second column, for "1897" read "1898;" line 3 from bottom, for "Fig. 8" read "Fig. 7;" line 2 from bottom, for "afternoon" read "morning." Page 108, column 1, line 18, for "Charts VII and VIII" read "Charts X and XI."

METEOROLOGICAL TABLES AND CHARTS.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only one observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation, the total depth of snowfall, and the mean wet-bulb temperatures. The altitudes of the instruments above ground are also given.

Table II gives, for about 2,700 stations occupied by voluntary observers, the highest maximum and the lowest minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (....).

Table III gives, for about 30 stations furnished by the Canadian Meteorological Service, Prof. R. F. Stupart, director, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values, except in the case of snowfall.

Table IV gives, for 26 stations selected out of 113 that maintain continuous records, the mean hourly temperatures deduced from the Richard thermographs described and figured in the Report of the Chief of the Weather Bureau, 1891–92, p. 29.

Table V gives, for 26 stations selected out of 104 that maintain continuous records, the mean hourly pressures as automatically registered by Richard barographs, except for Washington, D. C., where Foreman's barograph is in use. Both instruments are described in the Report of the Chief of the Weather Bureau, 1891–92, pp. 26 and 30.

Table VI gives, for about 130 stations, the arithmetical means of the hourly movements of the wind ending with the respective hours, as registered automatically by the Robinson anemometer, in conjunction with an electrical recording mechanism, described and illustrated in the Report of the Chief of the Weather Bureau, 1891–92, p. 19.

Table VII gives, for all stations that make observations at 8 a. m. and 8 p. m., the four component directions and the resultant directions based on these two observations only and without considering the velocity of the wind. The total movement for the whole month, as read from the dial of the Robinson anemometer, is given for each station in Table I. By adding the four components for the stations comprised in any geographical division the average resultant direction for that division can be obtained.

Table VIII gives the total number of stations in each State from which meteorological reports of any kind have been received, and the number of such stations reporting thunderstorms (T) and auroras (A) on each day of the current month.

Table IX gives, for about 70 stations, the average hourly sunshine (in percentages) as derived from the automatic records made by two essentially different types of instruments, designated, respectively, the thermometric recorder and the photographic recorder. The kind of instrument used at each station is indicated in the table by the letter T or P in the column following the name of the station.

Table X gives a record of rains whose intensity at some period of the storm's continuance equaled or exceeded the following rates:

Duration, minutes..	5	10	15	20	25	30	35	40	45	50	60	80	100	120
Rates pr. hr. (ins.)..	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.86	0.84	0.75	0.60	0.54	0.50

In the northern part of the United States, especially in the colder months of the year, rains of the intensities shown in the above table seldom occur. In all cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest rainfall of any single storm has been given, also the greatest hourly fall during that storm.

Table XI gives the record of excessive precipitation at all stations from which reports are received.

NOTES EXPLANATORY OF THE CHARTS.

Chart I.—Tracks of centers of high pressure. The roman letters show number and order of centers of high areas. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the 8 a. m. and 8 p. m., seventy-fifth meridian time, observations. The queries (?) on the tracks show that the centers could not be satisfactorily located. Within each circle is given the highest barometric reading reported near the center. A blank indicates that no reports were available. A wavy line indicates the axis of a ridge of high pressure.

Chart II.—Tracks of centers of low pressure. The roman letters show number and order of centers of low areas. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the 8 a. m. and 8 p. m., seventy-fifth meridian time, observations. The queries (?) on the tracks show that the centers could not be satisfactorily located. Within each circle is given the lowest barometric reading reported near the center. A blank indicates that no reports were available. A wavy line indicates the axis of a trough or long oval area of low pressure.

Chart III.—Total precipitation. The scale of shades showing the depth of rainfall is given on the chart itself. For isolated stations the rainfall is given in inches and tenths, when appreciable; otherwise, a "trace" is indicated by a capital T, and no rain at all, by 0.0.

Chart IV.—Sea-level isobars and isotherms, and resultant winds. The wind directions on this Chart are the computed